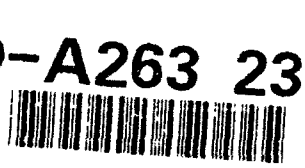


Effectiveness of Hand-Held Fire Extinguishers on Cargo Container Fires

Leroy Dickerson
David Blake

February 1993

DOT/FAA/CT-TN92/42

Document is on file at the Technical Center Library, Atlantic City International Airport, N.J. 08405

U.S. Department of Transportation
Federal Aviation Administration

Technical Center
Atlantic City International Airport, N.J. 08405

NOTICE

This document is disseminated under the sponsorship of the U. S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-TN92/42		

4. Title and Subtitle	5. Report Date
THE EFFECTIVENESS OF HAND-HELD FIRE EXTINGUISHERS ON CARGO CONTAINER FIRE	February 1993
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Leroy Dickerson and David Blake	DOT/FAA/CT-TN92/42
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405	Technical Note
	14. Sponsoring Agency Code ACD-240

15. Supplementary Notes

16. Abstract

The purpose of this project was to determine the effectiveness of fire-fighter intervention using hand-held fire extinguishers on fires in 150- and 800-cubic-foot cargo containers.

This test plan was undertaken following a fire in the main deck cargo compartment of a South African Airlines Boeing 747-244B (COMBI) on November 27, 1987. The airplane crashed into the Indian Ocean killing all occupants.

A total of 27 tests were performed; 23 in the 150-cubic-foot cargo container series, and 4 in the 800-cubic-foot cargo container series.

Three agents were tested--Halon 1211, Halon 1301, and "loaded stream" water. Only the Halon 1211 agent was partially successful in extinguishing this type of Class A fire. Seven of the 23 fires were extinguished. The rigid cargo containers contained and controlled the test fires through oxygen starvation in 18 of 20 fire tests that were not extinguished.

17. Key Words	18. Distribution Statement
Aircraft Cargo Fire Cargo Containers	Document is on file at the Technical Center Library, Atlantic City International Airport, New Jersey 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	18	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

EXECUTIVE SUMMARY

The purpose of this project was to determine the effectiveness of fire-fighter intervention using hand-held fire extinguishers on fires in 150- and 800-cubic-foot cargo containers.

This test plan was undertaken following a fire in the main deck cargo compartment of a South African Airlines Boeing 747-244B (COMBI) on November 27, 1987. The airplane crashed into the Indian Ocean killing all occupants.

A total of 27 tests were performed; 23 in the 150-cubic-foot cargo container series, and 4 in the 800-cubic-foot cargo container series.

Three agents were tested--Halon 1211, Halon 1301, and "loaded stream" water. Only the Halon 1211 agent was partially successful in extinguishing this type of Class A fire. Seven of the 23 fires were extinguished. The rigid cargo containers contained and controlled the test fires through oxygen starvation in 18 of 20 fire tests that were not extinguished.

INTRODUCTION

PURPOSE.

Tests were conducted to determine the effectiveness of fire-fighter intervention using hand-held fire extinguishers on fires in 150- and 800-cubic-foot cargo containers.

BACKGROUND.

This study addresses the application of fire extinguishers by a fire-fighter to extinguish or suppress a fire in a Class B cargo compartment fire protection plan. The tests involved fires in 150- and 800-cubic-foot cargo containers.

This series of tests were undertaken following a fire in the main deck cargo compartment of a South African Airlines Boeing 747-244B (COMBI) on 27 November 1987. Flight SA 295 departed at 14:23 from Taipei's Chaing Kai Shek Airport for Mauritius' Plaisance Airport with 159 persons on board. At approximately 23:48 the pilot radioed the Mauritius control and reported a smoke warning bell had sounded, indicating smoke in the main deck cargo compartment. At approximately 00:03:56 the controller cleared the flight for a direct approach. At approximately 00:04:02 the last communication was received from flight SA 295. The airplane crashed into the Indian Ocean at about 00:07:00 killing all occupants.

DISCUSSION

TEST DESCRIPTION.

Containers.

Twenty-seven tests were conducted to determine the effectiveness of hand-held fire extinguishers on fires in cargo containers. Tests 1 through 11 were conducted in a 150-cubic-foot rigid fiberglass container. Tests 12 through 23 were conducted in a 150-cubic foot aluminum container. Tests 24 through 27 were conducted in a 800-cubic-foot aluminum container (see table 1). Air leakage into the containers for most tests was limited to the natural leakage that occurred around the edge of the container door. See table 2 for test results.

Temperature, oxygen, and halon concentrations were measured and recorded once every 5 seconds; analyzer sample flow was monitored for the 60-minute test duration.

Agents.

1. 2.5-gallon "loaded stream" water (potassium carbonate) extinguisher

2. 2.5- and 17-pound Halon 1211 (bromochlorodifluoromethane) extinguishers

3. 3-pound Halon 1301 (bromotrifluoromethane) extinguisher

Fire Load.

The fire load for each test was cardboard boxes filled with shredded newspaper. Test containers were filled to approximately 90 percent capacity with the fire load.

Ignition Source.

The ignition source for all tests was a 6-foot length of nichrome wire, wrapped around two sheets of newspaper and placed in a box of shredded newspaper. This box was located in the center of the container fire load and remotely activated.

Agent Dispersion.

Agent was discharged into the containers from two locations. Ceiling discharge was via 3/8-inch-diameter copper tubing fabricated into an "X" shaped pattern (figures 1 and 2). The "x" grid legs were drilled with 1/32 inch holes every 6 inches of length at 90, 180, and 270 degrees, to provide a wide distribution of agent across the top of the test container. Agent was also discharged into the container through a port in the center of the side wall (figures 1 and 2).

Temperature Measurement.

Two chromel/alumel thermocouples were used to continuously measure temperature. One thermocouple probe was located below and in the center of the ceiling of the container (figures 1 and 2). The second thermocouple probe was placed in the fire load box adjacent to the igniter.

Gas Analysis.

Oxygen and Halon 1211 and 1301 concentrations were measured on a continuous basis, using a Beckman Model OM11-EA analyzer for oxygen and Beckman Model 865 infrared analyzer for halon gas. The sampling station was located in the center of the container ceiling (figures 1 and 2). The gas sample stream was piped back into the test container. See figure 3 for a schematic of the gas concentration measuring system.

TABLE 1. DESCRIPTION OF TESTS

150-CUBIC-FOOT CONTAINER TESTS

TEST 1 through 4 No agent used

TEST 1 and 2
Baseline test, natural leakage

TEST 3 and 4
To provide entry for extinguisher agent into the container, two 3/4-inch-diameter holes were drilled into the container upper sidewall to determine if the fire intensified because of the additional holes.

TEST 5 through 10--Halon 1211 used

TEST 5 and 6
Tests started with natural container leakage. At 10 minutes into the test, one 3/4-inch hole was uncovered and a 2.5-pound Halon 1211 extinguisher discharged into the container through the side wall input port.

TEST 7 and 8
Tests started with both 3/4-inch holes uncovered. At 10 minutes into the test, a 2.5-pound Halon 1211 extinguisher was discharged into the container through the side wall input port.

TEST 9
Container with natural leakage and a 15-ounce aerosol can with hydrocarbon propellant added to the fire load. At 5 minutes into the test, a 2.5-pound Halon 1211 extinguisher was discharged into the container through the side wall input port.

TEST 10
Container with natural leakage and a 15-ounce aerosol can with hydrocarbon propellent added to the fire load. At 5 minutes into the test, a 2.5-pound Halon 1211 extinguisher was discharged into the container through the ceiling input connection.

TEST 11--Halon 1301 used

TEST 11
Container with natural leakage. At 5 minutes into the test, a 3-pound Halon 1301 extinguisher was discharged into the container through the ceiling input connection.

TEST 12 and 13--"loaded stream" water extinguisher used

TEST 12 and 13
Container with natural leakage. At 5 minutes into the test, a 2.5-gallon "loaded stream" extinguisher was discharged into the container through the ceiling input connection.

TEST 14 through 23--Halon 1211 used

TEST 14 and 15
Container with natural leakage. At 5 minutes into the test a 17-pound Halon 1211 extinguisher was discharged into the container through the ceiling input connection.

TEST 16 and 17
Container with natural leakage. At 5 minutes into the test a 17-pound Halon 1211 extinguisher was discharged into the container through the side wall input port. Boxes (fire load) were placed 3 inches from inside container wall opposite agent input port, causing a back splash of agent of which a small quantity escaped from the container (figure 1).

TEST 18
Container with natural leakage. At 10 minutes into the test, a 17-pound Halon 1211 extinguisher was discharged into the container through the side wall input port.

TEST 19
Container with natural leakage. At 10 minutes into the test, a 17-pound Halon 1211 extinguisher was discharged into the container through the ceiling input connection.

TEST 20 and 21
Container with natural leakage. At 10 minutes into test, two 17-pound Halon 1211 extinguishers were discharged consecutively into the container through the ceiling input connection.

TEST 22 and 23
Container with natural leakage. At 10 minutes into test, two 17-pound Halon 1211 extinguishers were discharged consecutively into the container through the side wall input port.

800-CUBIC-FOOT MAIN DECK CONTAINER TESTS

TEST 24 through 27--ALL TESTS
Container with natural leakage. A 17-pound Halon 1211 extinguisher was discharged through the ceiling input connection 5 minutes after ignition. Rising temperature was criterion for discharging further extinguishers, also through the ceiling input connection.

TABLE 2. TEST RESULTS

TEST 1 and 2
No extinguisher used. Fire contained within container.

TEST 3 and 4
Drilled two 3/4-inch-diameter holes into upper sidewall of container. No extinguisher used. Fire contained within container. Fire did not intensify.

TEST 5 through 8
One 2.5-pound Halon 1211 extinguisher discharged 10 minutes after ignition.

NOTE: The container temperature is monitored during the fire test. When the container temperature returns to the ambient temperature, the fire inside the container is extinguished.

	DISCHARGE LOCATION	EXTINGUISHED YES	EXTINGUISHED NO	CONTAINED YES	CONTAINED NO	NOTES
5	SIDE		X	X		3/4" HOLES TAPED OVER
6	SIDE		X	X		
7	SIDE		X	X		3/4" HOLES TAPE REMOVED
8	SIDE		X	X		

TEST 9 and 10
One 2.5-pound Halon 1211 extinguisher discharged 5 minutes after ignition.

9	SIDE	X		X		15-OUNCE AEROSOL CAN PLACED IN IGNITION BOX. CAN BURST, BUT CONTENTS DID NOT IGNITE.
10	CEILING		X		X	AEROSOL CAN USED AS IN TEST 9. CAN BURST AT 43 MINUTES AND FORCED OPEN ONE SIDE OF THE CONTAINER DOOR. CONTENTS OF THE CAN IGNITED ABOUT 45 SECONDS AFTER CAN BURST.

	DISCHARGE LOCATION	EXTINGUISHED YES	EXTINGUISHED NO	CONTAINED YES	CONTAINED NO	NOTES
TEST 11 One 3-pound Halon 1301 extinguisher discharged 5 minutes after ignition.						
11	CEILING		X	X		
TEST 12 and 13 One 2.5 gallon "loaded stream" water extinguisher discharged 5 minutes after ignition.						
12	CEILING		X	X		
13	CEILING		X	X		
TEST 14 through 17 One 17-pound Halon 1211 extinguisher discharged 5 minutes after ignition.						
14	CEILING	X		X		
15	CEILING	X		X		
16	SIDE	X		X		
17	SIDE		X	X		
TEST 18 and 19 One 17-pound Halon 1211 extinguisher discharged 10 minutes after ignition.						
18	SIDE		X	X		
19	CEILING		X	X		
TEST 20 through 23 Two 17-pound Halon 1211 extinguishers discharged 10 minutes after ignition.						
20	CEILING		X	X		
21	CEILING	X		X		
22	SIDE	X		X		
23	SIDE		X	X		

TEST 24 through 27
17-pound Halon 1211 extinguishers used.

	NUMBER EXTINGUISHERS USED	EXTINGUISHED	NOTES
24	6	NO	
25	6	NO	CONTAINER DOOR OPENED, LATCH FAILED. NOT CONTAINED.
26	2	YES	
27	6	NO	

TEST RESULTS.

Agent was discharged in 23 of the 27 tests performed. Of those 23 tests the extinguishers actually extinguished the fire in seven tests (tests 9, 14, 15, 16, 21, 22, and 26). All but two of the test fires not extinguished (tests 10 and 25) were contained within the container and continued to smolder for the duration of the test.

Tests 1 through 23

These tests were conducted in the 150-cubic-foot container.

Tests 1 and 2

These were baseline tests for tests 3 through 8.

Tests 3 and 4

The holes had no effect on the fire.

Tests 5 through 8

Tests 3 through 8 were conducted to determine the effects on fire containment of two 3/4-inch-diameter holes in the upper side wall of the container. The results showed opening of the holes had no effect on the fire in the containers, and the fires were contained.

Tests 9 and 10

Aerosol cans were placed in the igniter boxes. In test 9, the can burst at approximately 7 minutes but did not ignite. The fire self-extinguished after 30 minutes. In test 10, the aerosol can burst at 43 minutes forcing one side of the container door open. The contents of the can ignited about 45 seconds later. After the contents ignited, the fire burned intensely, igniting the resin in the container walls and roof. The outside of the container was burning when the test was terminated.

Test 11

A 3-pound Halon 1301 extinguisher was used. Agent 1301 had little or no effect on the fire.

Tests 12 and 13

A 2.5-gallon "loaded stream" water extinguisher was used. This agent had no effect on the fire.

Tests 14 through 16

Tests 14, 15, and 16 (see figures 4, 5, and 6) fires were extinguished using one 17-pound Halon 1211 extinguisher, discharged 5 minutes after ignition. In tests 14 and 15, the agent was discharged through the ceiling grid. In test 16, the agent was discharged through the side wall port.

Test 17

One 17-pound Halon 1211 extinguisher was discharged 11 minutes after ignition through the side wall port: the fire was not extinguished. Note in test 17 (see figures 7, 8, and 9) although there was an initial extinguishment at about 11 minutes, reignition occurred at about 21 minutes. This demonstrates the importance of applying the agent early.

Tests 18 and 19

Conditions were identical to tests 14 through 17 except the agent was discharged 10 minutes after ignition. The fires were not extinguished.

Tests 20 through 23

Two 17-pound Halon 1211 extinguishers were discharged 10 minutes after ignition. Fires were extinguished in tests 21 and 22, but were not extinguished in tests 20 and 23.

Tests 24 through 27

These tests were conducted in the 800-cubic-foot container. Six 17-pound Halon 1211 extinguishers each were discharged in tests 24, 25, and 27. The fires were not extinguished. The fire in test 26 was extinguished after two 17-pound 1211 Halon extinguishers were discharged.

When the tests were terminated and the container doors were opened, flaming combustion occurred in almost all of the tests that were not extinguished. A water hose was used to extinguish the burning boxes. The boxes could not be extinguished while still inside the container. All of the burning boxes had to be removed from the container and thoroughly soaked with water to completely extinguish the fire.

SUMMARY OF RESULTS

1. The small (3/4 inch) holes in the 150-cubic-foot container sidewall had no effect on the fires intensity (tests 3 through 8).

2. Small quantities of Halon 1211 (2.5-pound extinguisher), Halon 1301 (3-pound extinguisher) and a 2.5-gallon "loaded stream" water extinguisher in the 150-cubic-foot cargo container had no effect on this type of Class A fire (tests 5 through 8, and 10 through 13).

3. Large quantities of Halon 1211 (17-pound extinguisher) discharged 5 minutes after ignition in the 150-cubic-foot cargo container were effective on this type of Class A fire (tests 14, 15, and 16).

4. Large quantities of Halon 1211 (17-pound extinguisher) discharged 10 minutes after ignition in the 150-cubic-foot cargo container were not effective on this type of Class A fire (tests 18 and 19).

5. Two 17-pound Halon 1211 extinguishers discharged 10 minutes after ignition in the 150-cubic-foot cargo container were effective in two out of four tests on this type of Class A fire (tests 21 and 22).

6. In the 800-cubic-foot cargo container tests, six 17-pound Halon 1211 extinguishers, the first discharged 5 minutes after ignition, were not effective on this type of Class A fire (tests 24, 25, and 27).

CONCLUSIONS

1. The agents tested, in the quantities normally found on aircraft, were only partially successful in extinguishing this type of Class A fire.

2. Aluminum and fiber glass containers (even with small holes) have high probability of containing and controlling fires through oxygen starvation (figure 8).

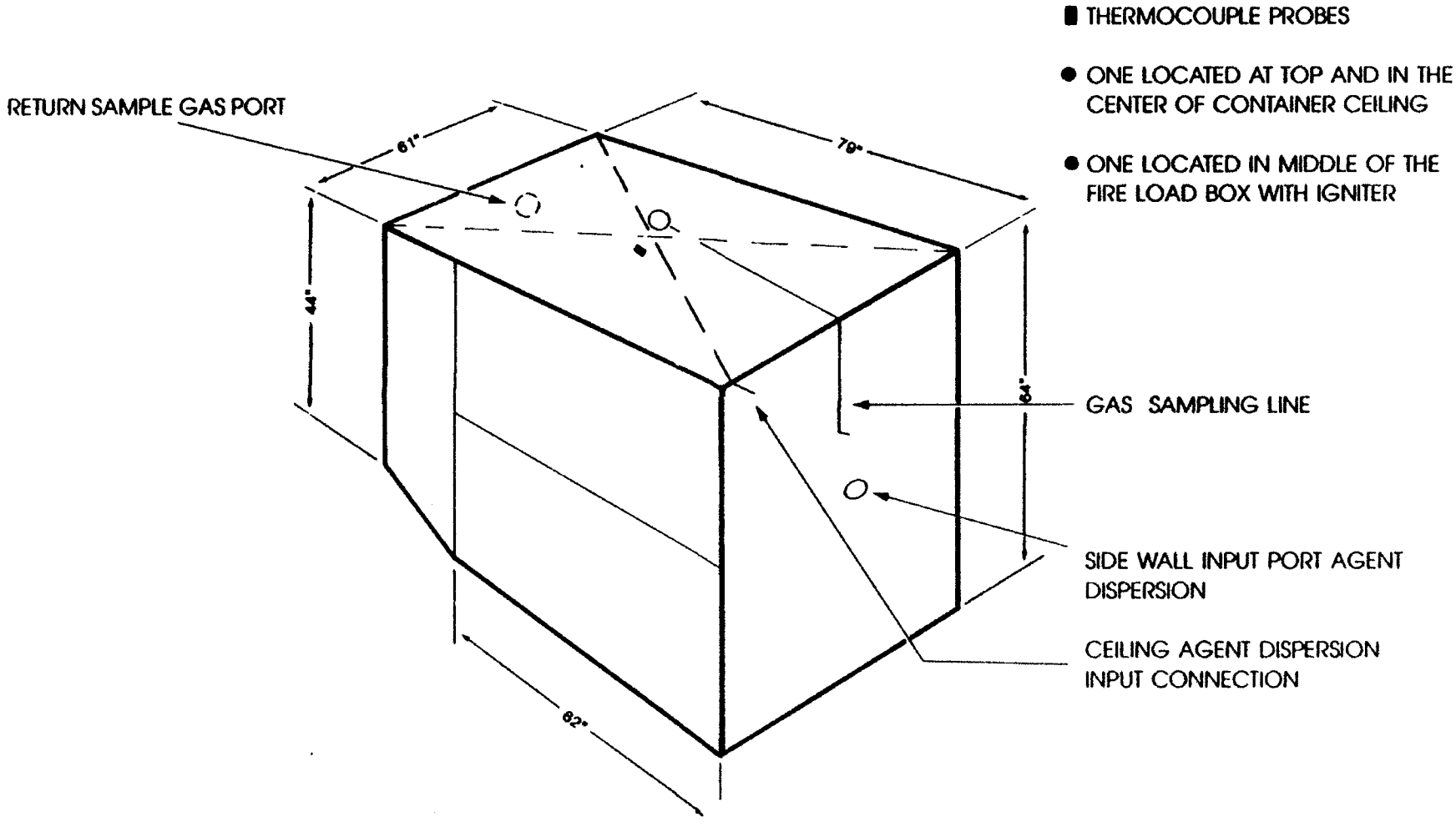


FIGURE 1. 150-CUBIC-FOOT CARGO CONTAINER

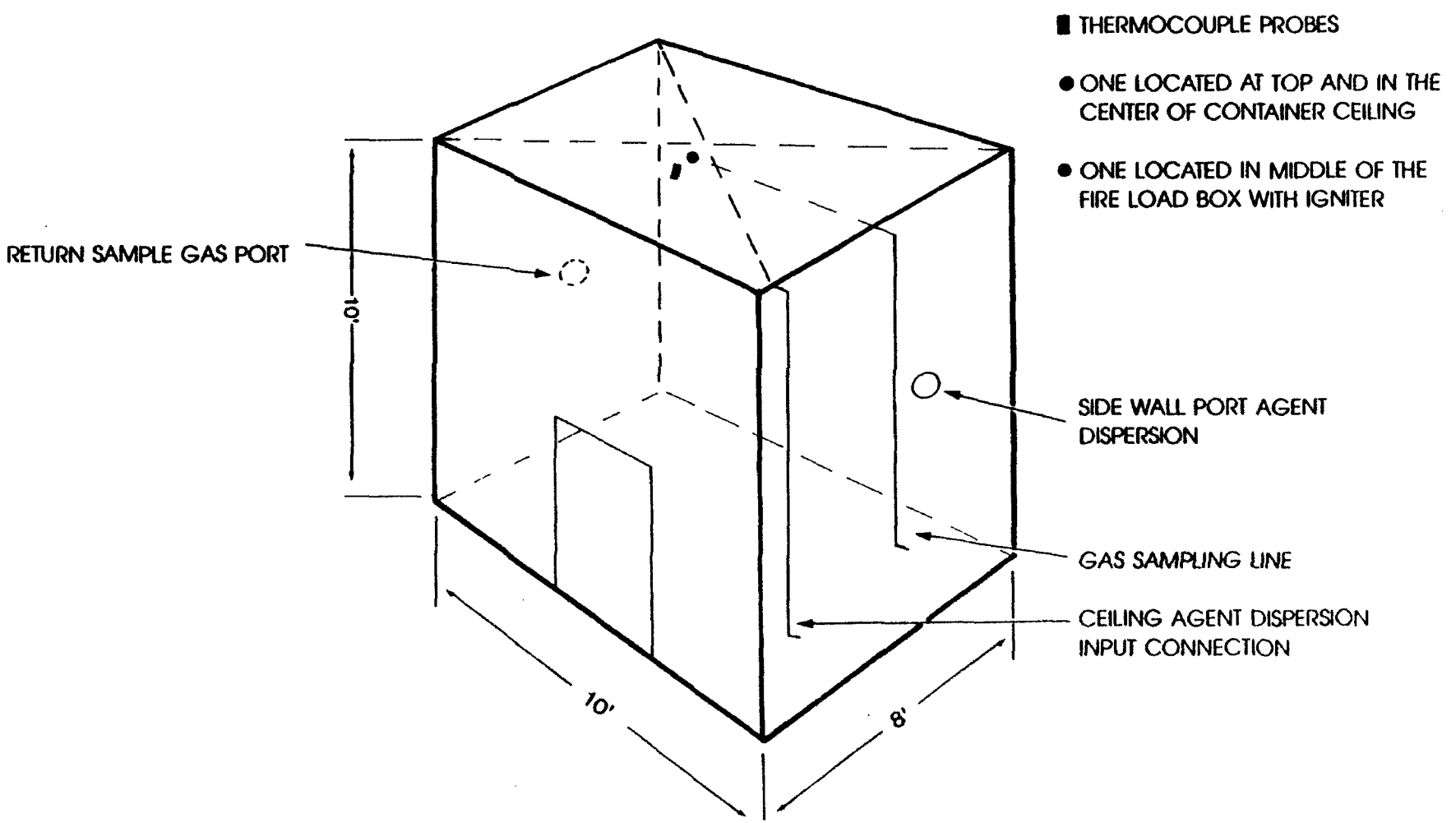
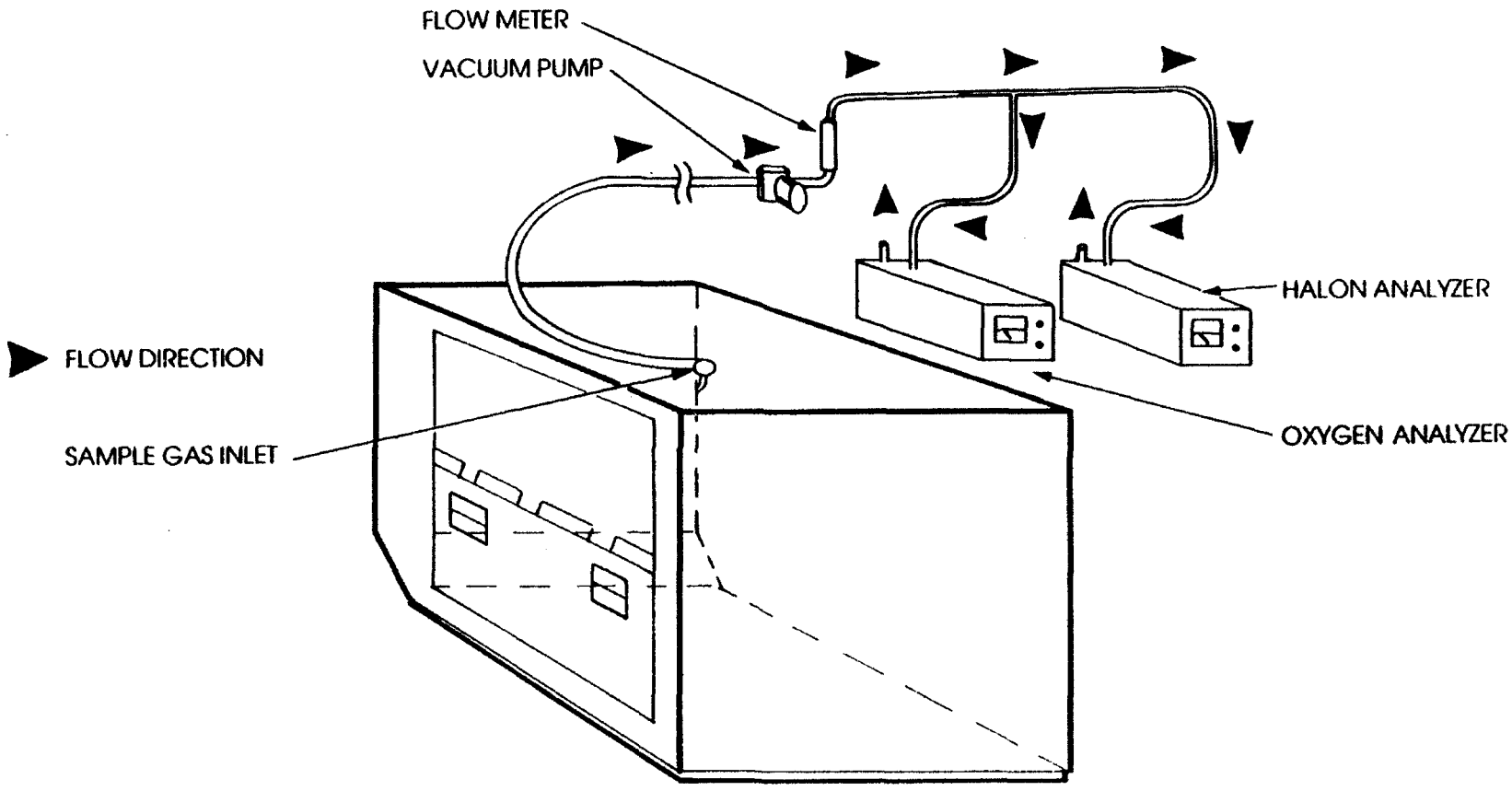


FIGURE 2. 800-CUBIC-FOOT CARGO CONTAINER



NOTE: SAMPLE GAS IS RETURNED INTO CONTAINER
AFTER BEING MEASURED.

FIGURE 3. SAMPLE GAS CONCENTRATION MEASURING SYSTEM

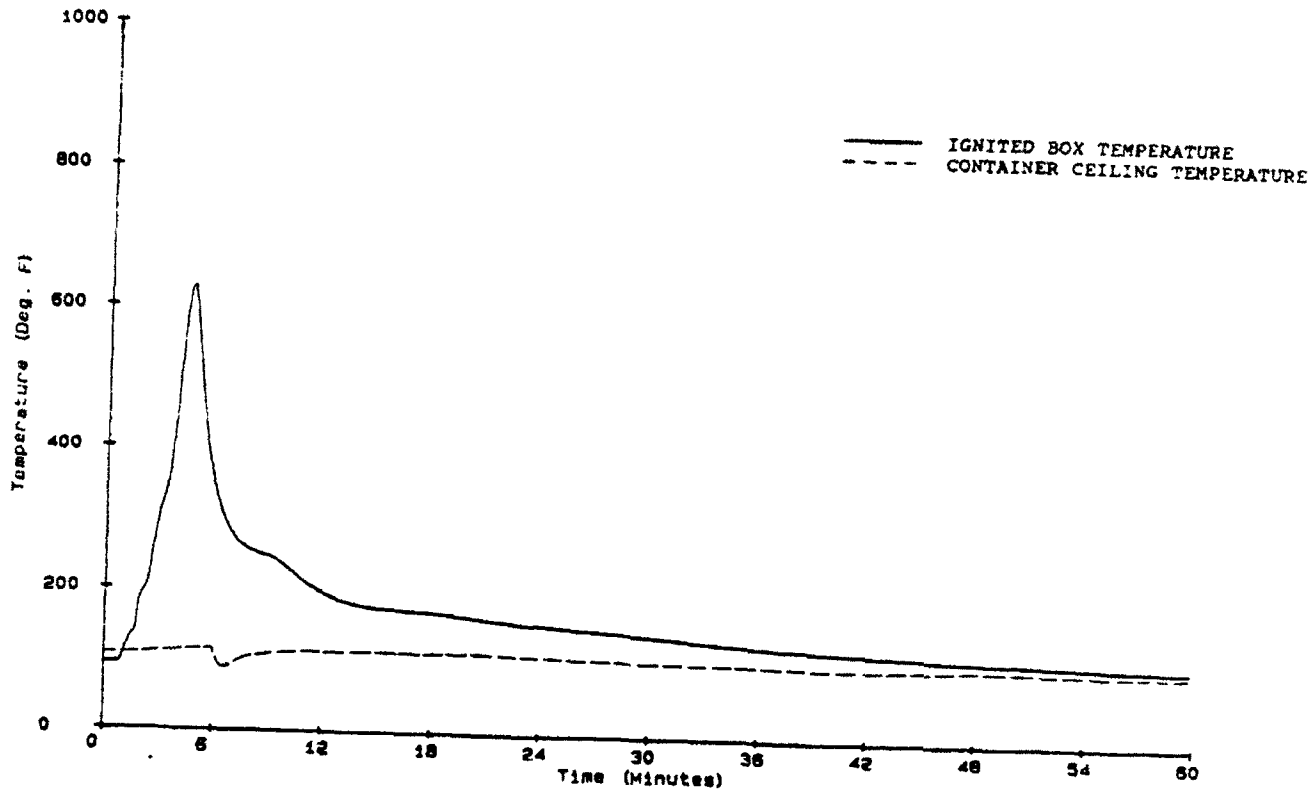


FIGURE 4. CONTAINER TEST NUMBER 16 - TEMPERATURE PROFILE

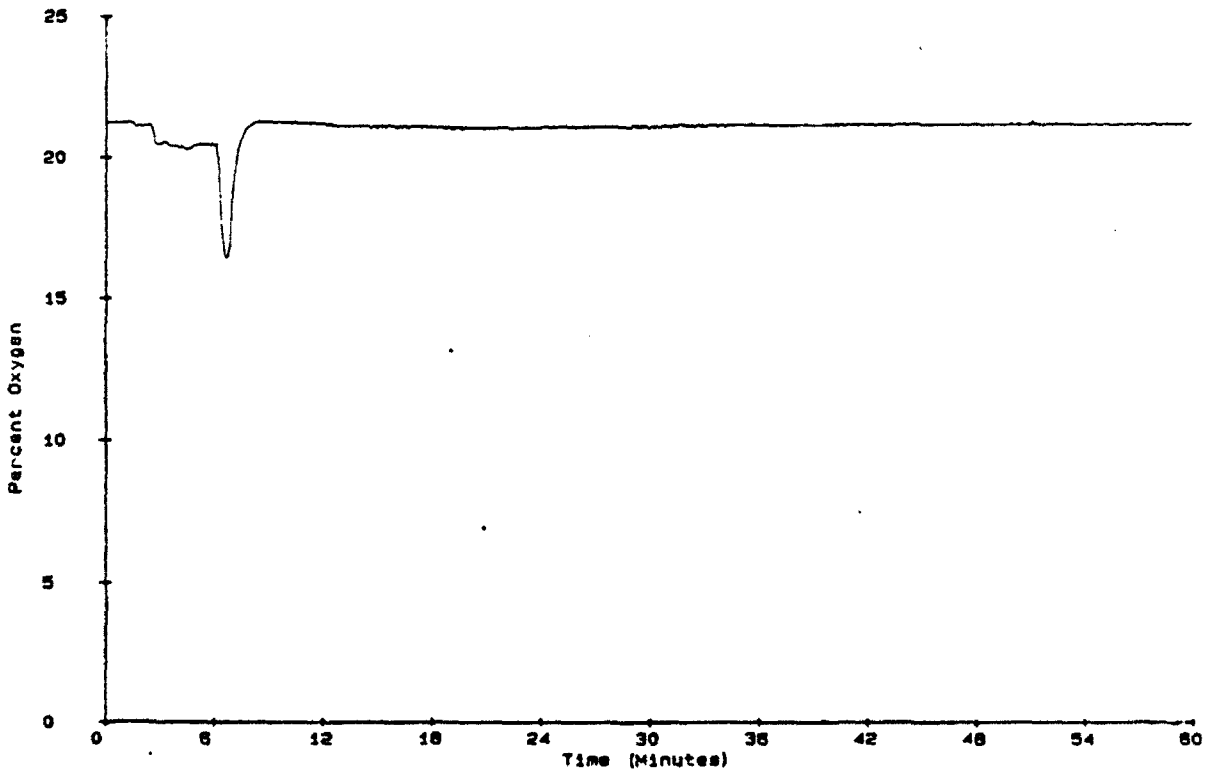


FIGURE 5. CONTAINER TEST NUMBER 16 - OXYGEN PROFILE

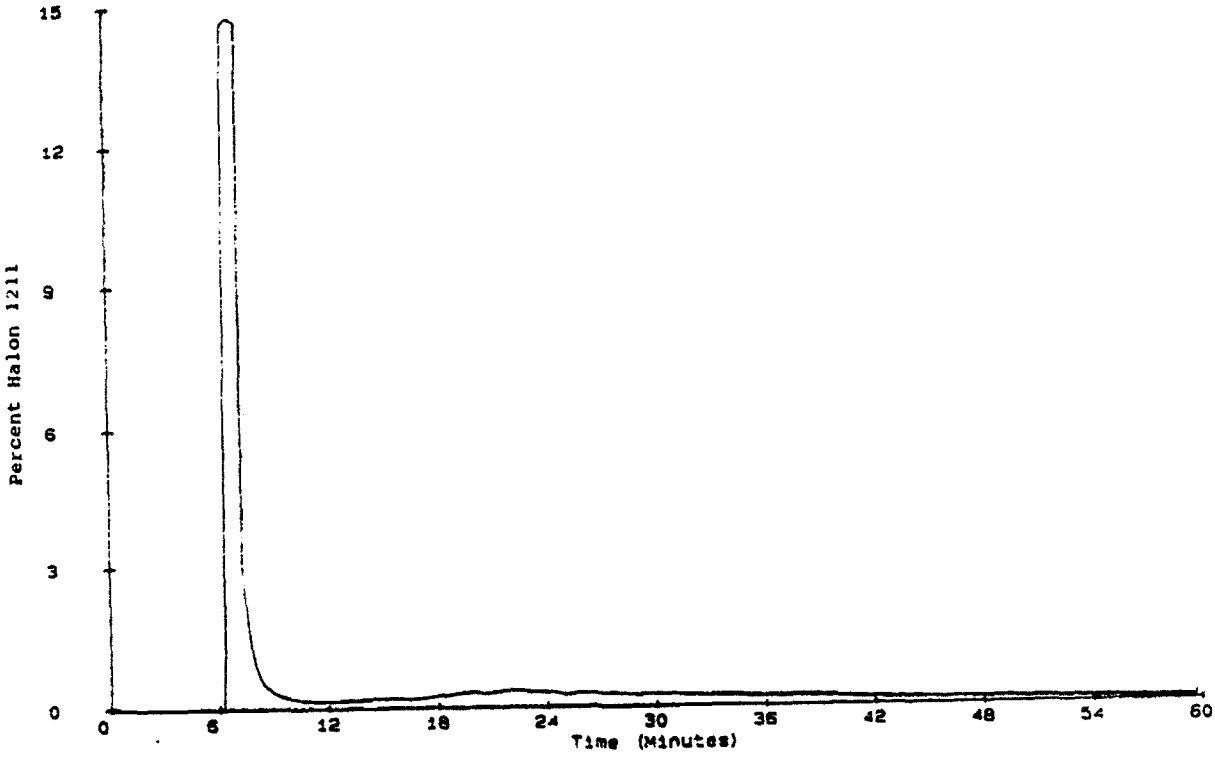


FIGURE 6. CONTAINER TEST NUMBER 16 - HALON PROFILE

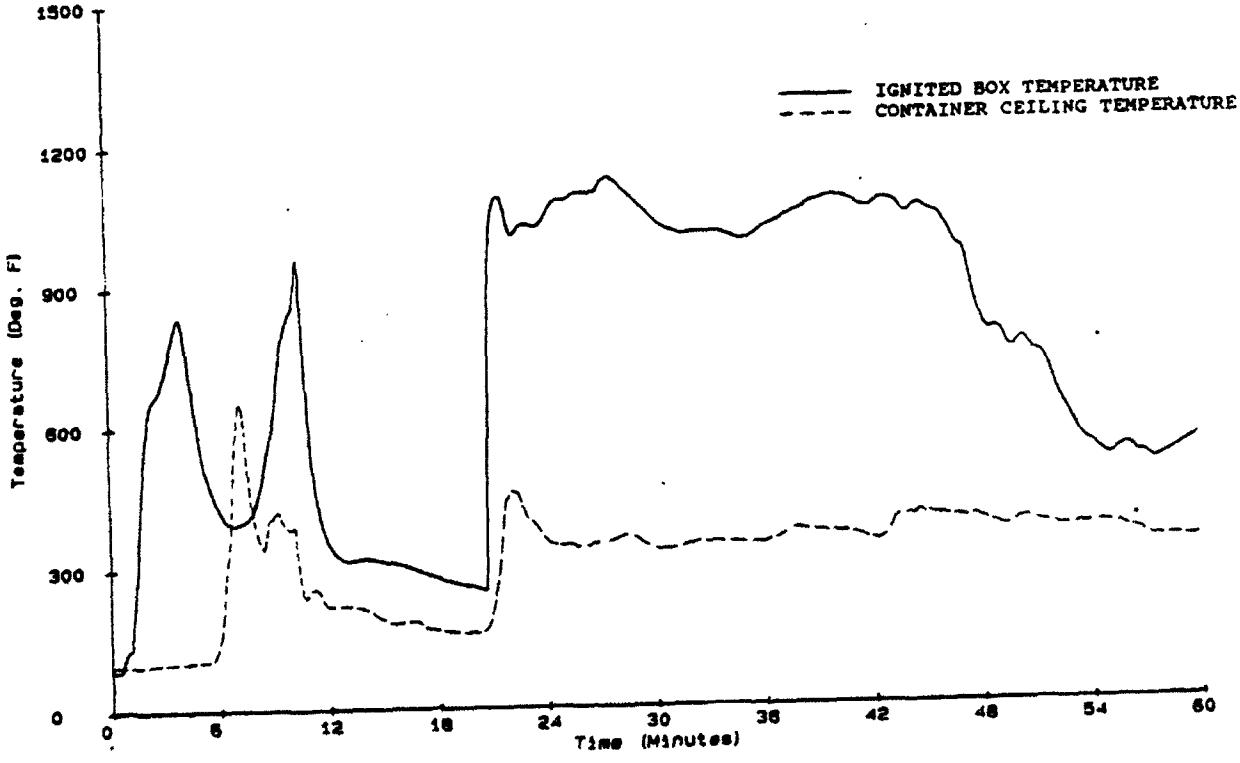


FIGURE 7. CONTAINER TEST NUMBER 17 - TEMPERATURE PROFILE

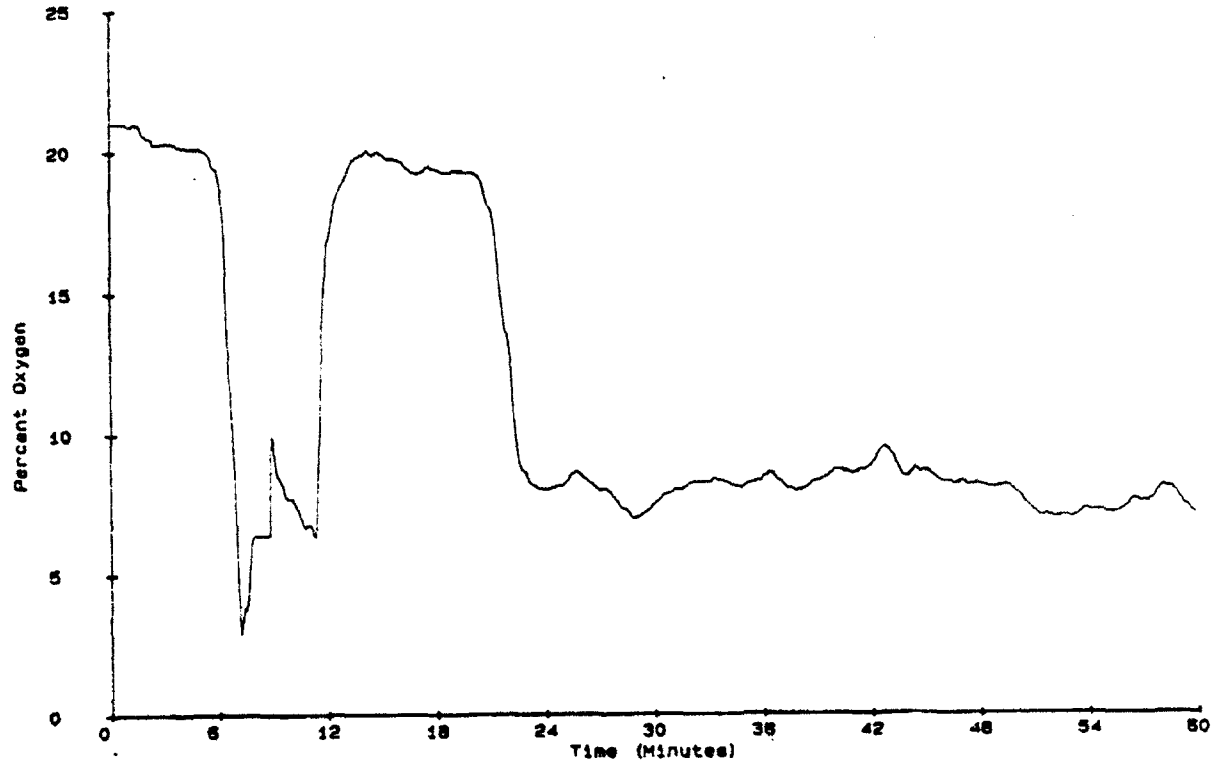


FIGURE 8. CONTAINER TEST NUMBER 17 - OXYGEN PROFILE

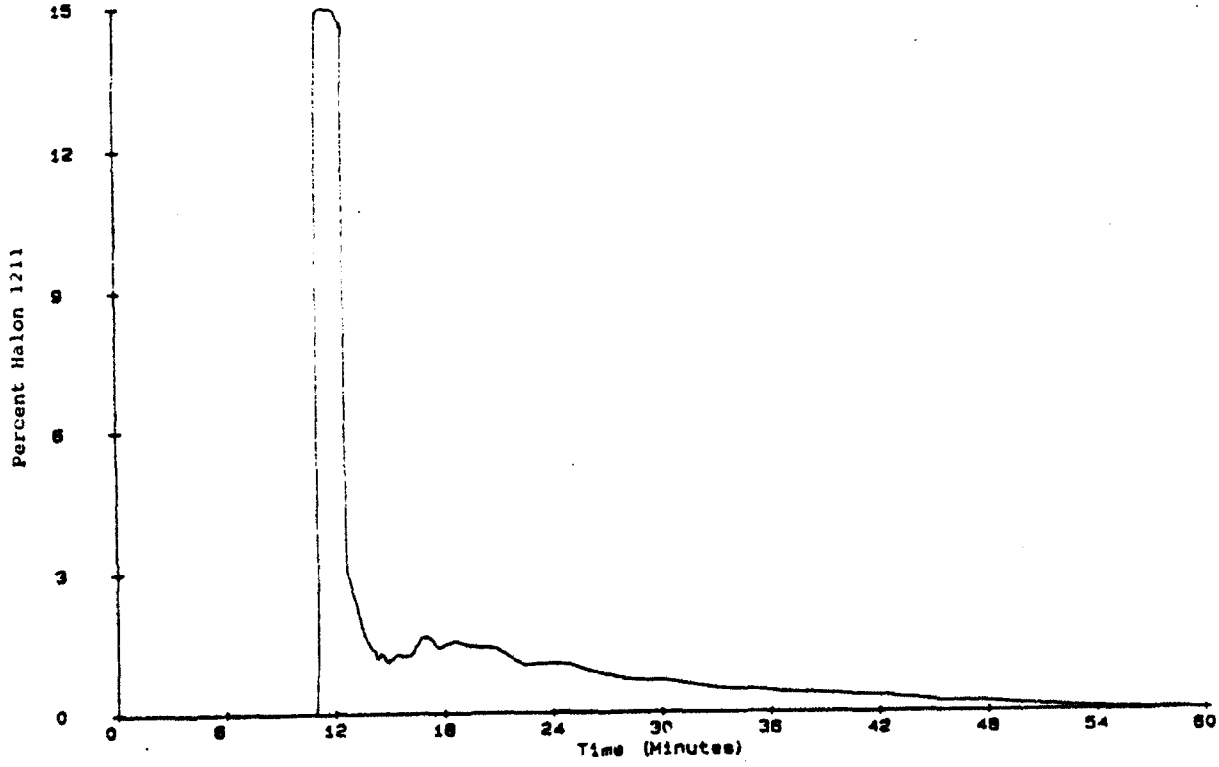


FIGURE 9. CONTAINER TEST NUMBER 17 - HALON PROFILE